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THE TRUCK/SHOVEL MINING AND OPERATING PRACTICES AT HIGHVALE MINE IN ALBERTA

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by

V. Srajer*

ABSTRACT

A general mine practices, operational planning and scheduling of the truck/shovel system as applicable to Highvale mine in Alberta, are described in this report. The selected factors, equations and practices used elsewhere are also discussed in the report and where practical, applied directly to Highvale mine operations.

This report is a part of the study of mining systems and practices at western Canadian surface coal mines. The data compiled in this report will be used in validation of computer model of truck and shovel systems presently under development at the National Research Council in Ottawa.

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MÉTHODES D'EXTRACTION ET D'EXPLOITATION MINIÈRES À L'AIDE D'UN SYSTÈME DE TRANSPORT CAMIONS-PELLES À LA MINE HIGHVALE EN ALBERTA

par

V. Srajer*

RÉSUMÉ

Le rapport porte sur les techniques générales d'exploitation minière, la planification du travail et l'établissement d'un programme ayant trait au système de transport camion-pelle. Les éléments sélectionnés de même que les méthodes et équations utilisées dans d'autres mines font également l'objet d'une étude et, le cas échéant, sont appliqués directement au mode de fonctionnement de la mine Highvale.

Le rapport fait partie d'une étude des systèmes et techniques d'exploitation minière dans les mines à ciel ouvert de l'Ouest canadien. Les données présentées dans ce rapport seront utilisées pour l'homologation du modèle automatisé d'un système de transport camion-pelle que le Conseil national des recherches est à mettre au point à Ottawa.

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1. INTRODUCTION

In this report the operating practices, planning and scheduling of the truck/shovel system used at Highvale Mine in Alberta, are described. The operation overview is followed by the description of trucks and shovels mining practices used at the Highvale Mine which include general practices useful in development of the Highvale Mine simulation model. The applicable factors, equations and practices used elsewhere are also listed in the report and where practical, they are recommended for application at Highvale Mine.

The presented report is a part of a study describing the Highvale Mine operating system. The study is a joint project of CANMET, National Research Council of Canada and TransAlta Utilities to develop and evaluate computer-based aids for the design and operation of surface coal mines in western Canada.

2. OPERATION OVERVIEW

The Highvale Mine is located on the south side of Lake Wabamun approximately 70 km west of Edmonton in the Province of Alberta. The access to the mine is via Highway 16 to Kapasiwin turnout and by the road along the south side of the Wabamun Lake.

The mine supplies coal to two electric power generating plants: Sundance (2100 MW) and Keephills (one 400 MW unit commissioned in 1983 and a second one is under construction). The mine is owned by TransAlta Utilities and operated under contract by Manalta Coal Ltd. The production at Highvale Mine commenced in 1970 at the rate of 4.5 Mt/year, rising to 7.8 Mt in 1981 and presently (1983) is 9.6 Mt.

The coal mined is classed as subbituminous "C" having a typical proximate analysis (1):

Moisture	21%
Ash	15%
Volatile	25%
Fixed carbon	39%
Heat value	1 860 MJ/kg

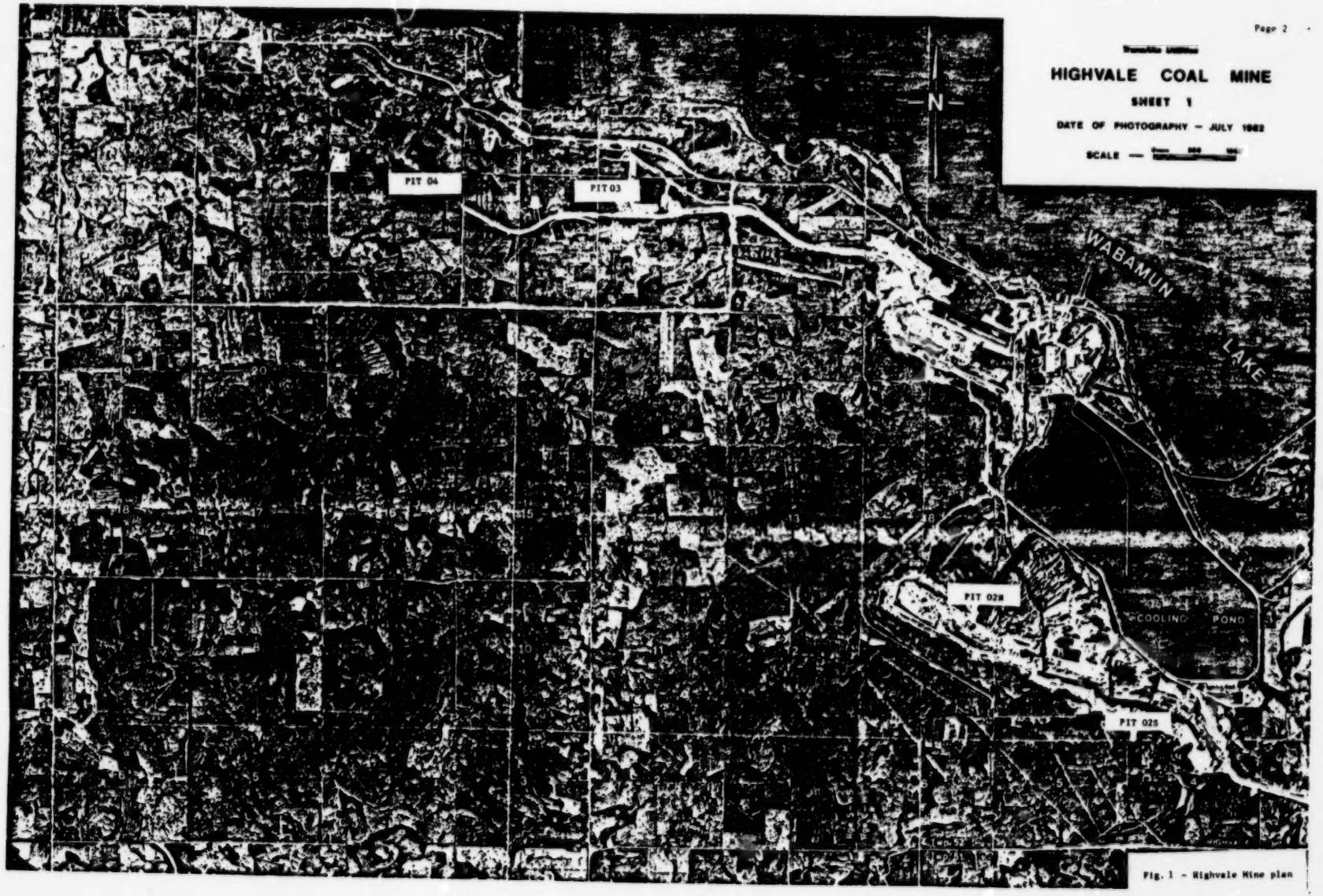

Fig. 1 – Highvale Mine plan

Total estimated recoverable reserves within the permit boundary are 1.046×10^{12} t(2). The weighted average recovery rate varies from 86.0% to 86.8%. The coal density is 1 394 kg/m^3.

The overburden is relatively thin (maximum 10 m). In the south section of the mine, not opened at the present time, the overburden ranges in depth from a few metres to 61 m. The overburden consist mainly of glacial till especially silty clay till interspersed with pebbles. The upper portion of overburden consists of wet, fibrous peat and muskeg. The prestripping of the peat and muskeg is required prior to application of any mining system. Remaining overburden is mostly glacial till having a moisture content in the range of 25-40%. The average in-situ bulk density of overburden is 1.92 t/bm^3 (2). Shales, siltstones, sandstones and bentonite clays form composition materials in the overburden.

During the field survey and study, the mine produces coal from three pits: Pit 02-south, Pit 03 and Pit 04. The location of the pits is apparent from the Highvale coal mine aerial photograph taken in July/1982 (Fig. 1).

The mining practice follows a pattern that appears to be standard for surface coal mines on the plains of western Canada. The upper part of the overburden (topsoil) is removed by scrapers. The thickness of the topsoil varies but generally is in the two to six metres range. The main part of the overburden is cast at spoil using draglines. The overburden in pits (02-S, 03 and 04) is removed by scrapers and draglines. There are three push-pull scrapers used to remove topsoil and upper subsoil, and three draglines to remove remaining overburden (BE-1360, Marion 8050, Marion 8750). The coal in five seams is removed by shovels - five operating at the time of study - and by one Lart 600C loader. The loader is also used to remove partings between seams. The mined coal is transported by trucks to Sundance or Keephills power generating stations. There are five seams mined at all three operating pits, called Nos. 1, 2, 3, 4 and 6. Seams No. 1 and 2 are 100% blasted and the top is ripped, Seams No. 3, 4 and 6 are ripped only. Partings between seams are removed by conventional scrapers and dozers or are pushed to the spoil side and removed by truck and loader or by shovel sidecasting methods.

The present pit operation at Highvale Mine can be characterized by the flow diagram in Fig. 2 (3).

The stripping operation is carried out seven days a week, 24 hours a day with the exception of an 8 hour planned maintenance shift. This maintains three months of stripped reserves of coal uncovered in the pits to supply the thermal plant in the event of a breakdown of the dragline.

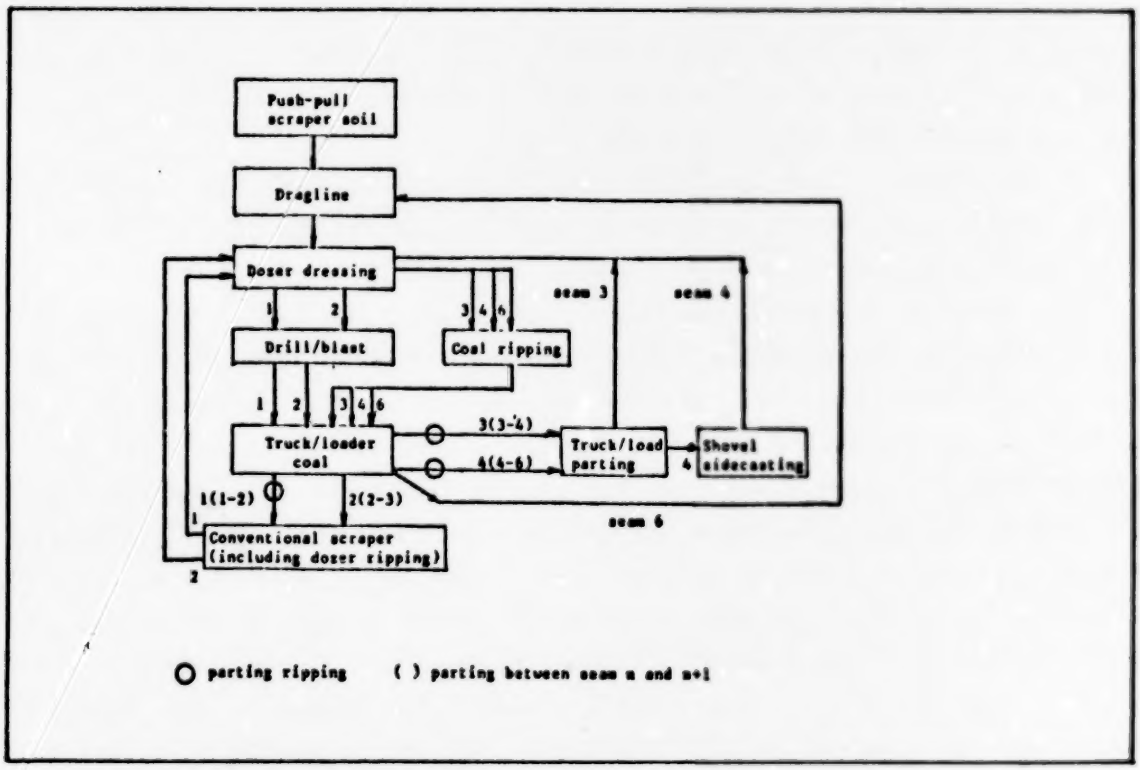

Fig. 2 - Job sequences

The coal is hauled to the processing plant using Euclid R85, Cat 772, Terex 34-11C and Kress CH-160 bottom-dump coal haulers. The trucking is done using 7 or 8 trucks - of the total of 14 - in two twelve hour shift operation daily.

Another significant part of trucking operation is placement of the ash from power plant inside spoil piles in the pit. Four Euclid R85 rear dump trucks are transporting ash from power plant loading dock back to the pit.

3. TRUCKS

3.1 DESCRIPTION OF OPERATION

At the time of writing this report, the Highvale Mine production was from three operating pits: Pit 02S, Pit 03 and Pit 04. Coal deliveries were to run-of-mine (ROM) hoppers at Sundance plant, for units 1 & 2, 3 & 4, and 5 & 6, to ROM. hopper no. 1 at Keephills plant, and to MCL stockpile. Hauling of the coal from Pits 3 and 4 were to Sundance ROM hoppers and the stockpile, hauling from Pit 02S were to Sundance or Keephills R.O.M. hoppers.

The loading of coal in pits was by the BE-190B electric shovels, two of them operating in Pit 02S (Nos. 1320 and 1353), two in Pit 03 (Nos. 1247 and 1337).

The coal haulers entered the pit by one ramp and exit the pit by other ramp. The assignment of travel direction at ramps was posted before each shift in the dispatch room. Several times, because of operational restrictions, only one ramp was used to enter and exit the pit. In this case, empty hauler yields to the loaded one.

In addition to coal bottom dump haulers, Highvale Mine has three end - dump trucks used for various light duties, for example for moving partings in the pit, or removing overburden at spoil side. Four ash haulers (Euclid R85: 77tonnes rear dump) are used to remove ash from the plant to the pit. During the time of the study, ash was deposited between spoils of Pit 02N. The D9L CATS are used to level and spread ash between spoil piles.

There are two dump sites at Sundance ROM hopper: two on the north side are for unit 1 & 2 and 3 & 4, and one on the south side for unit 5 & 6. There is one way entry for the traffic at both locations, controlled by light

warning systems. A green light is for an "open" hopper, red for "closed" hopper. The signal is clearly visible to truckers at distance.

3.2 ROLLING RESISTANCE TESTS

During August of 1983 TransAlta Utilities tested their trucks for rolling resistance factors. The tests were for dry conditions only and give the following results (Table 1). The rolling resistance tests were evaluated and compared with the test results collected elsewhere (4) to obtain values recommended for the Highvale Mine (Table 2).

Table 1 - Rolling resistance test results

No.	Location of test	Resist. factor (kg/t)	Gr. Equivalent (%)
1.	North of NR5 after topsoil and subsoil removed-unloaded truck	40	4.0
2.	Same as No. 1 - loaded truck	45	4.5
3.	Ramp 31 - loose gravel	27	2.7
4.	Pit 03 - subsoil stockpile	44	4.4
5.	Pit 04 - box cut	41	4.1
6.	Pit 04 - box cut after topsoil and subsoil excavation	67	6.7
7.	Pit 04 - subsoil stockpile	82	8.2
8.	Pit 02N - ramp no. 6	39	3.9
9.	Haul road to Keephills	20	2.0
10.	Pit 02N - levelled spoil	73	7.3

Table 2 - Recommended rolling resistance values for Highvale Mine

Rolling resistance (% grade equivalent)	Location at Highvale
2.0	All haul roads
2.2	Access ramps at Sundance and Keephills R.O.M. hoppers
2.5	All haul roads in winter
2.7	All ramps with partially loose gravel, ramp 32, 33
3.0	All ramps to pits, slightly flexing under load, ramp 31
3.5	Ramps to Pit 02N
4.0	Ramps to Pit 03, winter ramp to Pit 02N
4.5	All roads with fresh loose snow, subsoil stockpiles
5.0	Dirt road with little or no maintenance, well packed pit bottom
6.0	Pit bottom in average condition, haul road after heavy rain
7.0	Fresh excavation
8.0	Subsoil stockpile, ramp after heavy rain
9.0	Loose sand and gravel
10.0	Muddy roadway, in-pit condition
20.0	Muddy surface with no gravel

In general the rolling resistance factor increases with a decrease of the bearing power of the material used for road construction.

3.3 TRUCK PERFORMANCE

For calculation of the rimpull-speed-gradability curves, retarder curves, brake performance curves, and travel time curves, the following formula for rolling resistance was adopted (4):

R.R(%) = R.R.(% from Table 2) + 0.6% per (cm)of tire penetration.

The rolling resistance and grade of the road when added will give the effective grade. In the Highvale Mine area, the main haul roads are constructed up to 4% grade, and up to 8% in pit or at ramps. The tire penetration measured in (Kg/cm/t) is of course different for each type of tires and in fact equal to continuous uphill grade. In general, hard tires have less tire penetration and tire flexing than soft tires on similar ground. Tire flexing (in kg/t) for radial tires is only 75% that of standard tires. In addition to the tire penetration and tire flexing, the internal friction of moving parts in truck is another significant performance limiting factor.

For measurement of the percent grade which can be climbed by a vehicle of a given weight and power, gradability factor is used (4,5):

$$\text{Gradability} = \frac{\text{kg of Rimpull} \times 100\%}{\text{vehicle weight (kg)}} - \text{R.R.(\%)}.$$

The gradability in our calculation was not used, because its value is dependent on a specific vehicle weight requiring new curves to be drawn for each change in vehicle weight.

The grade resistance was calculated for each section of the road (Table 5) and the values were used in determination of overall grade resistance. Another term introduced, grade assistance, is used for vehicles moving down an incline and for the calculation of retarder curves.

The rimpull or pulling force of the tires on the ground, were calculated from the rimpull curves (plot of rimpull vs KPH). As vehicle speed increases, rimpull decreases.

The traction from the ground condition will keep the wheel from spinning, depending on road material and vehicle weight. There is never 100% adhesion, so the coefficient of traction is always less than 1.0. The maximum force which can be transmitted on a wheel before the tire spins out is calculated as (4):

$$\text{Max force} = \text{weight on drive axle} \times \text{coeff. of traction.}$$

All-wheel drive vehicle have 100% of the vehicles weight on the drive axle and thus are capable of delivering more of the rimpull available than are single drive axle vehicles.

In Table 3, the coefficient of traction for various ground conditions are summarised:

Table 3 - Coefficient of traction

Material	Coefficient of traction
Contrete	.90
Hard rock	.65
Packed earth	.60
Dry clay loam	.55
Wet Clay loam	.45
Loose earth	.45
Coal on stockpile	.45
Rutted clay loam	.40
Wet sand	.40
Loose gravel	.35
Dry sand	.20
Packed snow	.20
ice	.10

An increase in altitude may cause a decrease in engine performance, because the change in the air density and the fuel-to-air ratio in the combustion chamber of the engine. The Highvale Mine elevation is in range from about 700 m to 770 m above sea level. Based on information from manufacturers, no loss in the performance is expected from sea level to about 300 m. The Rimpull values should then be reduced by 1% for every 100 m. Therefore, the rimpull values for Highvale Mine should be reduced by 4.0 to 4.7%. It is recommended to use 4.3% reduction for average elevation of the mine area. This reduction is valid for 4-cycle diesel engine naturally aspirated only. The reduction for 2-cycle diesel engine is about half of the 4-cycle engine.

To establish criteria for the down grade performance of vehicles, the retarder curves are used. The retarder is a device for a dynamic braking and is located (for example in Terex truck), between torque converter and the transmission gear. The retarder is used on long and steep downhill hauls. On most haul roads at Highvale Mine service brakes will be sufficient to maintain speed control. One possible exception will be a section of the south road between SH7 ad SR1 and a section of the north road between NR3 and NR2. Fully loaded coal haulers are expected to run on the north road section

only. The section on the south road, in south-west direction, is travelled by empty haulers only, except for Euclid R81 rear-dump trucks hauling ash to Pit 02N.

Generally, the retarder works by converting mechanical power in the wheel into the heat in the oil that will dissipate through the cooling system. The retarder must be used to slow down the truck travelling at speed above 8 km/hr.

3.4 TIRES

The tires constitute the most important cost element of the vehicle. Therefore it is of great importance that proper selection of tires is made for the specific job and proper maintenance procedure is implemented.

The use of "TKPH" or "Ton-Kilometer-Per-Hour" formulae was introduced to govern the load that is carried by the trucks in terms of the tonnage capacity. The "TKPH" factor will integrate speed of the vehicle into the tire loading. The formulae is important for estimating life of the tire by monitoring heat of air in the tire. The tires are manufactured by vulcanizing the ply's in tire at temperature of about 140°C. During the use of the tires, the tire increases its temperature because of the heat generated by flexing under load while rolling, and therefore a reversion from a vulcanizing process can take place at about 140°C. In addition, at temperatures below this point, the strength of the rubber is reduced and impact damage can occur. The high temperature will result in ply separation and the tire failure.

The increased temperature depends on:

a. load over individual tire
b. speed of the vehicle
c. ambient temperature.

To use tires correctly the following points must be observed:

a. correct pressure
b. specific load
c. maximum speed
d. proper maintenance of vehicle
e. proper maintenance of haul road.

Table 4 - Tire life factors

GROUP A - MAINTENANCE (includes installation)	
Excellent	1.1
Average	1.0
Poor	0.7
Very bad	0.4
GROUP B - MAXIMUM SPEEDS	
15 km/h	1.2
30 km/h	1.0
45 km/h	0.8
65 km/h	0.5
GROUP C - CURVES	
None	1.1
Moderate	1.0
Severe with single wheels	0.8
Severe with dual wheels	0.7
Severe with tandem wheels	0.6
GROUP D - HAUL ROADS & WORK AREAS	
Snow packed, no road exposed	3.0
Hard, packed earth	1.0
Soft earth or sand, maintained	1.0
Soft earth or sand, some rock	0.8
Mud, ordinary	0.8
Mud, abrasive or with rock	0.5
Gravel road, well maintained	0.9
Gravel road, poorly maintained	0.7
Blasted material - soft coal	0.9
Blasted material - soft shale or limestone	0.7
Blasted material - granite, gneiss, trap, basalt, hard shale, limestone	0.6
Blasted material - slate or schist	0.4
Blasted material - lava, hard surface	0.3
Blasted material - obsidian, volcanic glass, flint	0.1
Blacktop - clean, wet	1.4
Blacktop - cold weather	1.2
Blacktop - 40°-75°F	1.0
Blacktop - 75°-100°F	0.8
Blacktop - over 100°F	0.5
GROUP E - TIRE LOADS	
50% underload	1.2
20% underload	1.1
Recommended by tire & rim ass'n	1.0
10% overload	1.0
20% overload	0.8
40% overload	0.5
GROUP F - WHEEL POSITION	
Front (non-driving)	0.9
Driving - hauler	0.6
hauler tandem	0.7
bottom dump	0.7
scraper	0.6
front-end loader	0.6
Trailing	1.0
GROUP G - GRADES, DRIVE TIRES ONLY	
Level	1.0
Firm surface - 6% maximum	0.9
10% maximum	0.8
15% maximum	0.7
25% maximum	0.4
Loose or Slippery Surface - 6% maximum	0.6
10% maximum	0.6
15% maximum	0.4
GROUP H - MISCELLANEOUS CONDITIONS	
Favourable or counteracting	1.5
None	1.0
Unfavourable	0.8
Very unfavourable	0.6

The formaulae for "TKPH" calculation is (5):

$$\text{TKPH} = \text{mean tire load} \times \text{ave. speed/day} \quad [\text{tkm/h}]$$

where

$$\text{Mean tire load} = [\text{tire load (empty)} + \text{tire load(loaded)}]/2$$

and

$$\text{Ave. work-day speed} = \frac{\text{round trip distance} \times \text{no. of cycles/day}}{\text{total operating hours/day}}$$

The "TKPH" is supplied by the tire manufacture for each type of tire. In our calculation the rating for ambient temperature at 38°C used by Bridgestone (5) is recommended.

A method of estimating the tire life recommended for our project was taken from the Terex handbook (6). It was assumed that a maximum life of tire is 1000 hrs. The tire life is multiplied by factors which account for speed, curves, loads, grades, etc. Table 4 presents the factors for eight basic conditions. The product of a factor from each of the eight conditions multiplied by 6 000 hrs will give a reasonable estimate of the tire life for various conditions.

For vehicles at Highvale Mine the following factors were applied (Table 5).

Table 5 - Highvale Mine tire life factors

Factor	Coal haulers	Ash haulers
A	1.0	1.0
B	0.5	0.5
C	1.0	1.0
D	0.9	0.9
E	1.0	1.0
F	0.7	0.8
G	0.8	0.8
H	1.5	1.5
TOTAL	0.38	0.43

In conclusion, the tire life for coal haulers at Highvale Mine is estimated at 2 280 operating hours and the tire life for ash haulers at 2 580 operating hours.

The tire operating ability as a function of mean operating speed-average work day speed and mean tire load for each "TKPH" rating is in following graph (Fig. 3).

3.5 LOADING

For truck modelling purposes the following factors are needed:

a. time to move to preload position

b. time from preload to load position

c. loading

d. moving out.

Actual values were measured during the time studies at the Highvale Mine. The theoretical values could be obtained by using known equations and generally acceptable criteria.

For calculation of load (bank m^3):

$$\text{Load} = \text{loose } m^3 \times \text{load factor}$$

where

$$\text{Load factor} = \frac{100\%}{100\% + \%\text{swell}}$$

Table 6 - Load factors (4)

Swell (%)	Load factor	Voids (%)
5	.952	4.8
10	.909	9.1
15	.870	13.0
20	.833	16.7
25	.800	20.0
30	.769	23.1
35	.741	25.9
40	.714	28.6
45	.690	31.0
50	.667	33.3
55	.645	35.5
60	.625	37.5
65	.606	39.4
70	.588	41.2
75	.571	42.9
80	.556	44.4
85	.541	45.9
90	.526	47.4
95	.513	48.7
100	.500	50.0

Load factors for various materials are listed in the Table 6 for various swell of the material. A list of load factors for selected material is in Table 7 with weight of the material in loose or bank kg/m^3. The weight of material listed is for average condition. It varies with moisture content, grain size, degree of compaction, etc.

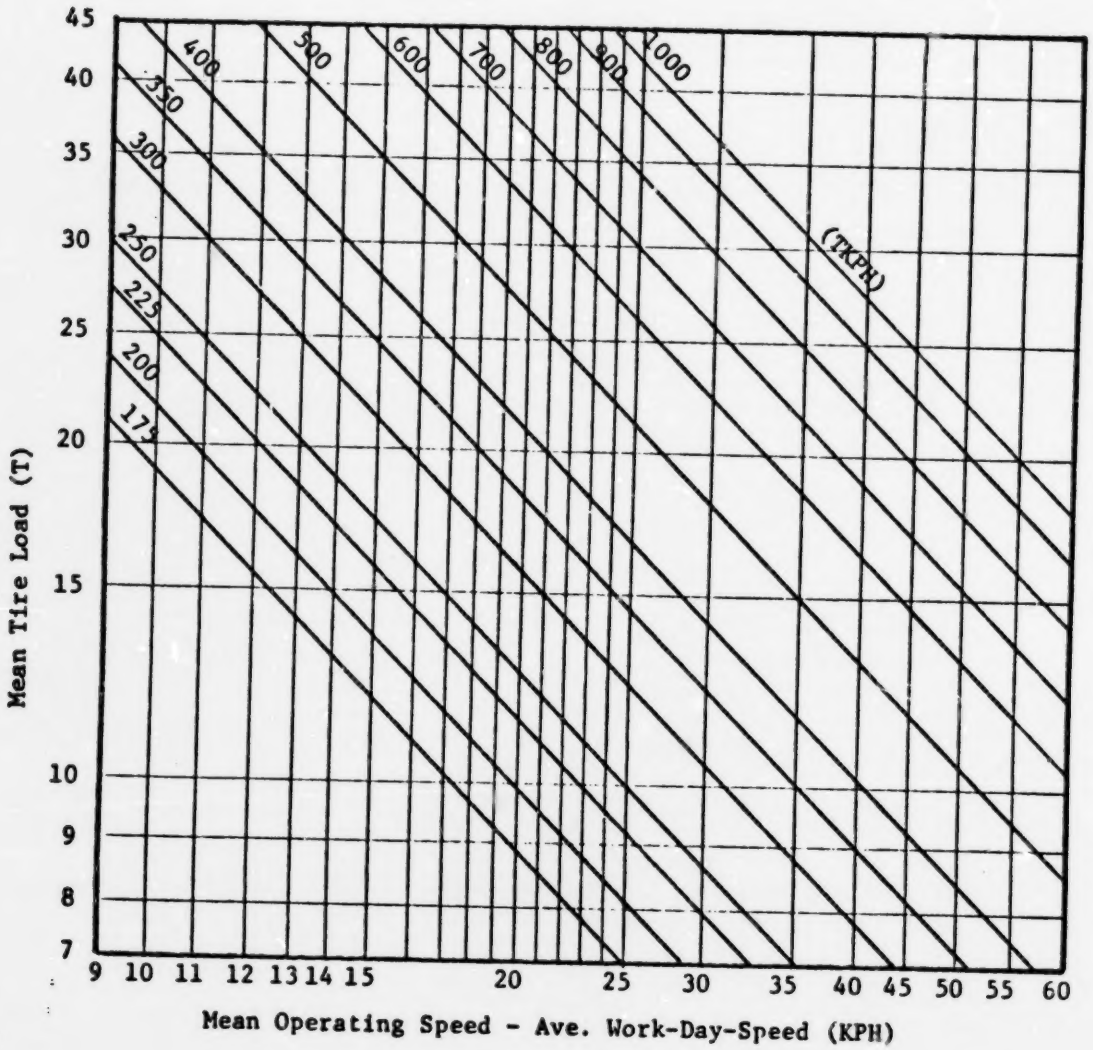

Fig. 3 - Tire operating ability

Table 7 - Load factors for selected material (4)

Material	Load factor	Weight	
		Loose (kg/m^3)	Bank (kg/m^3)
Clay - natural	.82	1 660	2 020
- dry	.81	1 480	1 840
- wet	.80	1 660	2 080
Clay & gravel - dry	.85	1 420	1 660
- wet	.85	1 540	1 840
Coal - antracite, raw	.74	1 190	1 600
washed	.74	1 100	-
- bituminous, raw	.74	950	1 280
washed	.74	830	-
- subbituminous	.93	650	890
Ash	.93	530	590
Earth - dry packed	.80	1 510	1 900
- wet excav	.79	1 600	2 020
- loam	.81	1 250	1 540
Gravel - pit run	.89	1 930	2 170
- dry	.89	1 510	1 690
- dry (6-50 mm)	.89	1 690	1 900
- wet (6-50 mm)	.89	2 020	2 260
Limestone - broken	.59	1 540	2 610
- crushed	-	1 540	-
Sand - dry, loose	.89	1 420	1 600
- damp	.89	1 690	1 900
- wet	.89	1 840	2 080
Sand & clay - loose	.79	1 600	2 020
- compacted	-	2 400	-
Sand & gravel - dry	.89	1 720	1 930
- wet	.91	2 020	2 230
Sandstone	.60	1 510	2 520
Shale	.75	1 250	1 660
Stone - crushed	.60	1 600	2 670
Top soil	.70	950	1 370

The loading time is determined by multiplying the loading rate for bucket capacity illustrated in Table 8 with dipper factor from Table 9 and known material weight for truck payload rating:

$$\text{Load time} = \frac{\text{payload rating (kg)}}{\text{loading rate (loose m}^3\text{/min) x dipper factor x material weight (kg/loose m}^3\text{)}}$$

The payload is limited by the heaped capacity of the truck body or by the load rate. It is not known which payload will govern, therefore both load times should be calculated and the lower used.

The dipper factor (or bucket factor) is a percentage of a shovel capacity that can be filled with a specific material in a specific form. The dipper factor multiplied by the dipper capacity of a specific shovel will give the approximate loose measure volume of material in the shovel. From Tables 8 and Table 9, the proper dipper factor can be selected for most conditions. To obtain an accurate loading rate, the output shovel rate should be multiplied by the proper dipper factor.

Table 8 - Bucket capacity of shovels (6)
(for 90° swing)

Bucket capacity (m^3)	Loose m^3/hr for:		
	Easy digging	Med. digging	Hard digging
.60	127	106	89
.76	163	136	116
1.15	235	191	169
1.91	367	290	263
2.29	430	338	306
2.68	492	388	346
3.06	548	430	388
3.44	605	378	427
3.82	684	523	467
4.20	714	566	508
4.59	768	610	548
4.97	822	651	590
5.35	875	706	627
6.12	979	787	705
6.88	1 089	879	787
7.64	1 208	971	856
8.41	1 315	1 055	933
9.17	1 422	1 147	1 009
9.94	1 529	1 231	1 086
10.70	1 636	1 315	1 154
11.47	1 751	1 399	1 231

Table 9 - Dipper factor for shovels (6)

Easy digging	Med. digging	Hard digging	Rock
0.85 - 1.00	0.80 - 0.90	0.70 - 0.80	0.40
Loose, soft, free running materials. Close lying, which will dipper or bucket to capacity and frequently provide heaped load.	Harder materials that are not difficult to dig without blasting, but break up with bulkiness causing voids in dipper or bucket.	Materials requiring some breaking up by high blasting or shaking. More bulky and somewhat hard to penetrate, causing voids in dipper or bucket.	Blasted rock, hardpan and other bulky materials, which cause considerable voids in dipper or bucket and are difficult to penetrate.
Dry sand or small gravel. Moist sand or small gravel. Loam Loose earth Muck Sandy clay Loose clay gravel Bituminous coal Cinders or ashes Very well blasted material.	Clay-wet or day Coarse gravel Clay gravel, packed. Packed earth. Anthracite coal.	Well broken limestone rock and other blasted rocks. Blasted shale Ore formations (not of rock character-requiring some blasting. Heavy wet, sticky clay. Gravel with large boulders. Heavy, wet gumbo. Cemented gravel.	
NOTE: Condition is the digging face of sufficient length to allow dipper to obtain loads as given			

The above factors and equations should be ultimately used and stored in the data base of truck/shovel model.

3.6 DUMPING

Dumping of coal at Highvale Mine was studied at Sundance and Keephills hoppers, and on MCL stockpile. Dumping of ash was studied at the spoils dump in Pit 02N.

Dumping at the Sundance is by assignment of trucks to hopper 3-4 or 5-6. At the beginning of the shift the driver is assigned to dump its load at a specific hopper. Thi? hopper is also identified by a green flashing light. The driver continues to drive to an assigned location till he is asked to do otherwise or when they see a red flashing light at hopper. There is one way traffic at Sundance hoppers.

Dumping at Keephills hopper is by assignment and generally, only for trucks loading in Pit 02S. There is only one dumping location at Keephills hopper which is controlled by a flashing light. During our observation, no truck was required to return from the dump because of a red flashing light, indicating full or non-operating dump, but this alternative should be considered in the model.

Dumping at MCL stockpile was introduced by Manalta, who are contracted by TransAlta Utilities to have spare coal capacity in the event of disruption of work at the mine. Trucks entering the dump area drive over the stockpile and slowly dump coal while driving.

Ash trucks are loaded at ash loading station and the load is dumped between spoils in Pit 02N. Ash trucks used are the rear-dump only version only. Significant time is spent maneuvering at dump site, queuing and moving from the dump site. A front-end loader is used to spread the ash between spoilsand to clear an access path for next truck. During heavy rains, when ground conditions deteriorate, operations stop completely.

It is recommended to use times measured in the field for estimating dumping times in the computer model. The mathematical formulaes will not improve the actual model specification, it will only serve to make the model only more complicated. Alternative assesses at dump sites are discussed in the report "Model specification of truck/shovel system" (8).

During the field study in 1983, only one truck broke down at dump site which blocked the access for all the other trucks. The trucks were immediately diverted to other dump site by the dispatcher in the control tower and the defective truck was removed in 25 minutes.

3.7 AVAILABILITY AND UTILIZATION

The Highvale Mine maintenance management office keeps track of all equipment records. The equipment time is broken down into four categories:

a. operating time (A)
b. down time (B)
c. delays (C)
d. idle (D)

Total time (E) is a summary of all times. The individual times are recorded daily and a report is issued monthly.

To calculate equipment utilization, the following equations are used:

Mechanical availability: A/(A+B)

Average index: (A+C+D)/(A+B+C+D)

Utilization index: (A+C)/(A+C+D)

Absolute utilization: (A+C)/E

Operating efficiency: A/(A+C)

These events are defined as follows:

Operating Time

The hours the machine is actually operating. This includes moving between pits or between locations within a pit, or moving to or from the shop, providing it is in working condition and is moving under its own power.

Down Time

Down time means the time the machine is down for repair or PM, including waiting for parts or repair. Down time takes priority over delay or idle time.

Delay

The delay time includes:

- Power outages for electric equipment.
- F.O.G. - daily servicing/fueling only.
- Interruption of production while waiting for another unit i.e. haulers waiting for a shovel to move to another location (does not include shovel repositioning or waiting for another hauler to be loaded).
- Lunch and miscellaneous breaks (shift changes).
- Start up and shutdown.
- No work available but scheduled.
- Safety and union meeting
- Weather
- Blasting
- Operator no-shows or tardiness
- Ash haulers waiting on TransAlta's fly ash trucks.

For shovels only:

a. waiting for haulers is not a delay and is included in operating time.

b. moves longer than 15 minutes are considered as delays.

Idle Time

Idle time means any non-scheduled time when the machine is not operational, i.e. weekend, third shift, etc. This event does not include any repairs performed during the idle time, but can include servicing on a non-scheduled shift, if servicing is done during lunch and coffee breaks.

Using TransAlta's records for the period of April 1982 to December 1983, such time indicators can be determined. In Figs. 4 to 8, the graph of operational and non-operational hours is presented separately for each type of truck The values used in calculation are in the computer file "Highvale Mine" accessed is by using [HGV:1 to 5] files as listed in Table 10.

Table 10 - List of files

Trucks	Computer file	Figure	Note
Euclid R85:77T	HGV-1	4	Ash haulers
Euclid R85:91T	HGV-2	5	Coal haulers
Cat 772:91T	HGV-3	6	Coal haulers
Terex 34-11C:136T	HGV-4	7	Coal haulers
Kress CH-160:145T	HGV-5	8	Coal haulers

The following Table 11 summarizes total operating and non-operating hours for the period of Apr/1982 to Dec/1983.

Table 11 - Summary of hours

Trucks type	Oper. hrs. A	Downtime B	Delays C	Idle D	Total E
Euclid R85:77T	738	256	165	177	2 926
Euclid R85:91T	1 700	982	486	489	3 657
Cat 772:91T	396	455	220	286	1 358
Terex 34-11C:136T	1 515	675	372	363	2 926
Kress CH-160:145T	1 025	613	259	109	2 006
Average	1 075	596	300	285	2 574
Ash	738	256	165	177	2 926
Coal	1 159	681	334	312	2 486

It is recommended that the model will use variances as indicated for each month in Files HGV:1-5 with the provision that the data will be constantly updated, so that a more realistic value would be available in the future. It is assumed that five year averages for each type of truck will satisfy the requirement.

Using standard equations, the mechanical availability, average index, utilization index, absolute utilization and operating efficiency are calculated and are summarized in Table 12 for ash trucks and in Table 13 for coal trucks.

Table 12 - Ash trucks indicators

Truck	Mech. avail. A/(A+B)	Aver. index (A+C+D)/(A+B+C+D)	Util. index (A+C)/(A+C+D)	Absol. util. (A+C)/E	Oper. effic A/(A+C)
Euclid R85:77T	0.7425	0.8084	0.8361	0.3086	0.8173

Table 13 - Coal haulers indicators

Truck	Mech. avail. A/(A+B)	Aver. index (A+C+D)/(A+B+C+D)	Util. index (A+C)/(A+C+D)	Absol. util. (A+C)/E	Oper. effic. A/(A+C)
Euclid R85	0.6338	0.7315	0.8172	0.5978	0.7777
Cat 772	0.4653	0.6647	0.6829	0.4536	0.6429
Terex 34-11C	0.6918	0.7692	0.8387	0.6449	0.8029
Kress CH-160	0.6258	0.6944	0.9218	0.6401	0.7982
Average	0.6295	0.7260	0.8273	0.6005	0.7762

From the above tables it is apparent that the mechanical availability of ash haulers is about 12% higher than coal haulers, and that operating efficiency is about 5% higher for ash haulers.

When comparing mechanical availability of individual types of coal haulers, Terex trucks are above average and Caterpillar trucks are 35% below average. The operating efficiency of Euclid, Terex and Kress trucks are about the same, Caterpillar trucks are 20% behind average.

Nevertheless, these indicators alone, considered without load factors, will not give comparable values. The truck with 20% better utilization is no better than a truck with average utilization but 30% higher load factor. Therefore, to compare hauled tonnages at the mine, coal and ash hauler load factors were developed.

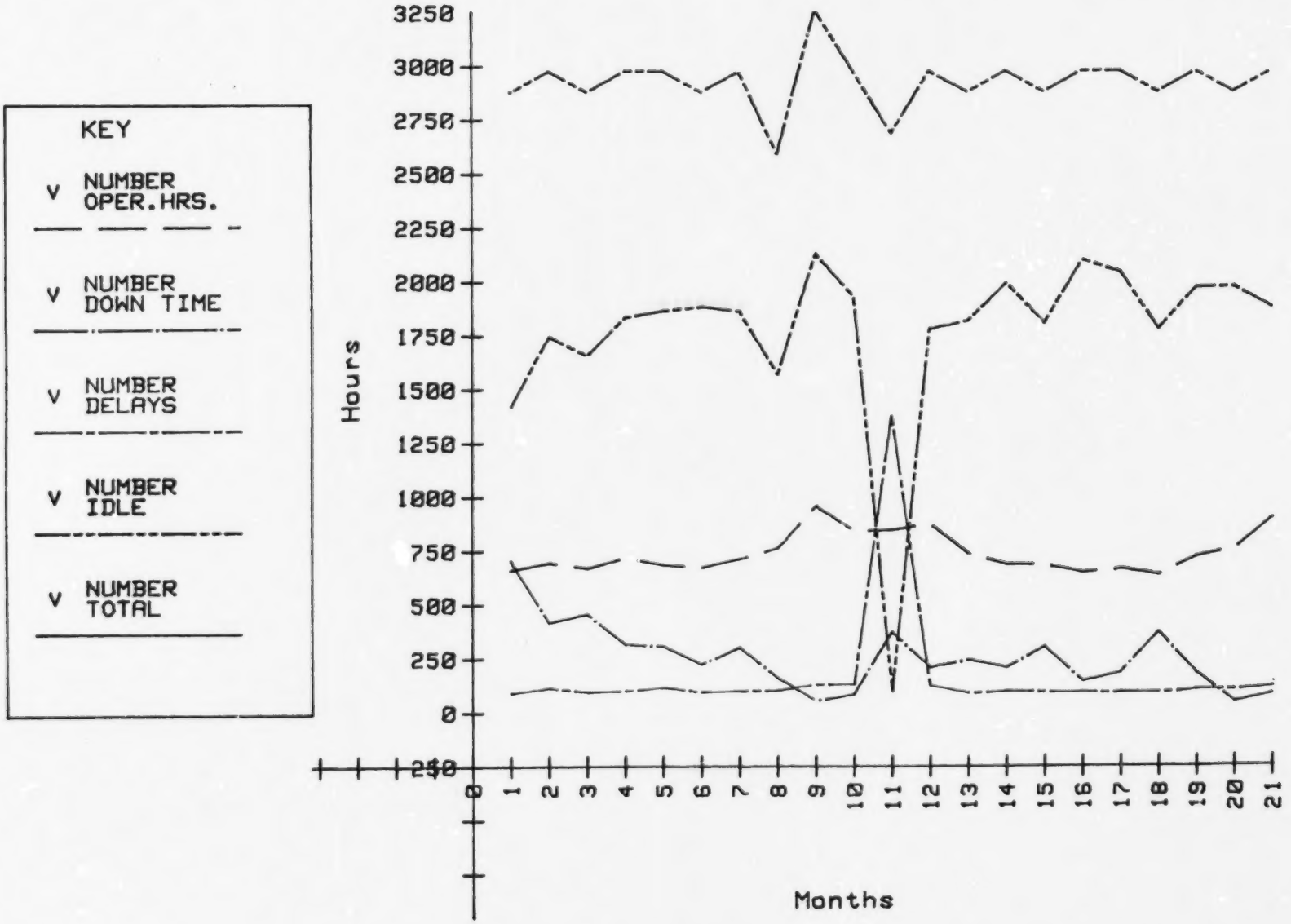

Fig. 4 - ASH HAULERS SUMMARY OF HOURS
EUCLID R85:77 Tonnes

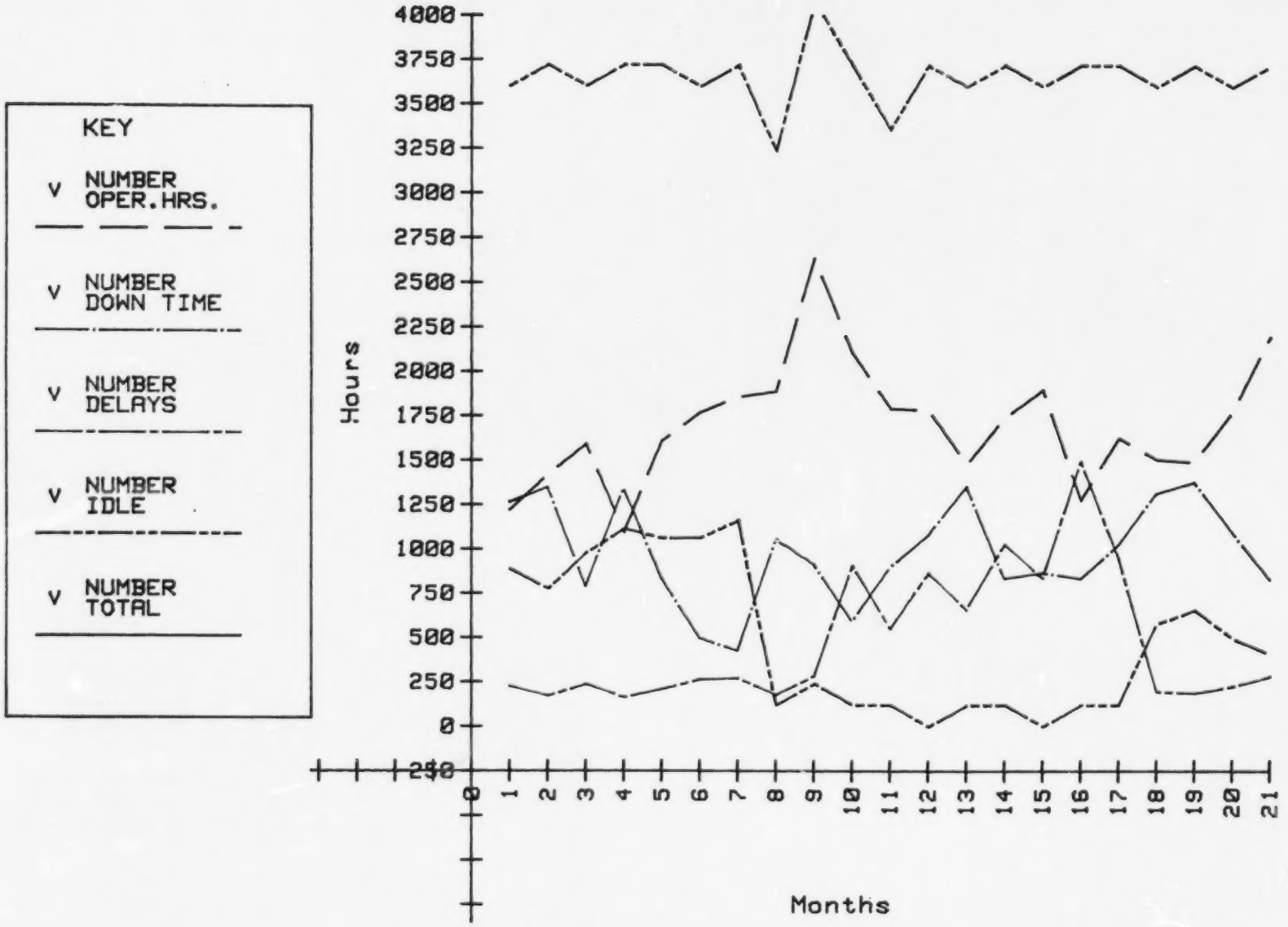

Fig. 5 - COAL HAULERS SUMMARY OF HOURS
EUCLID R85:91 Tonnes

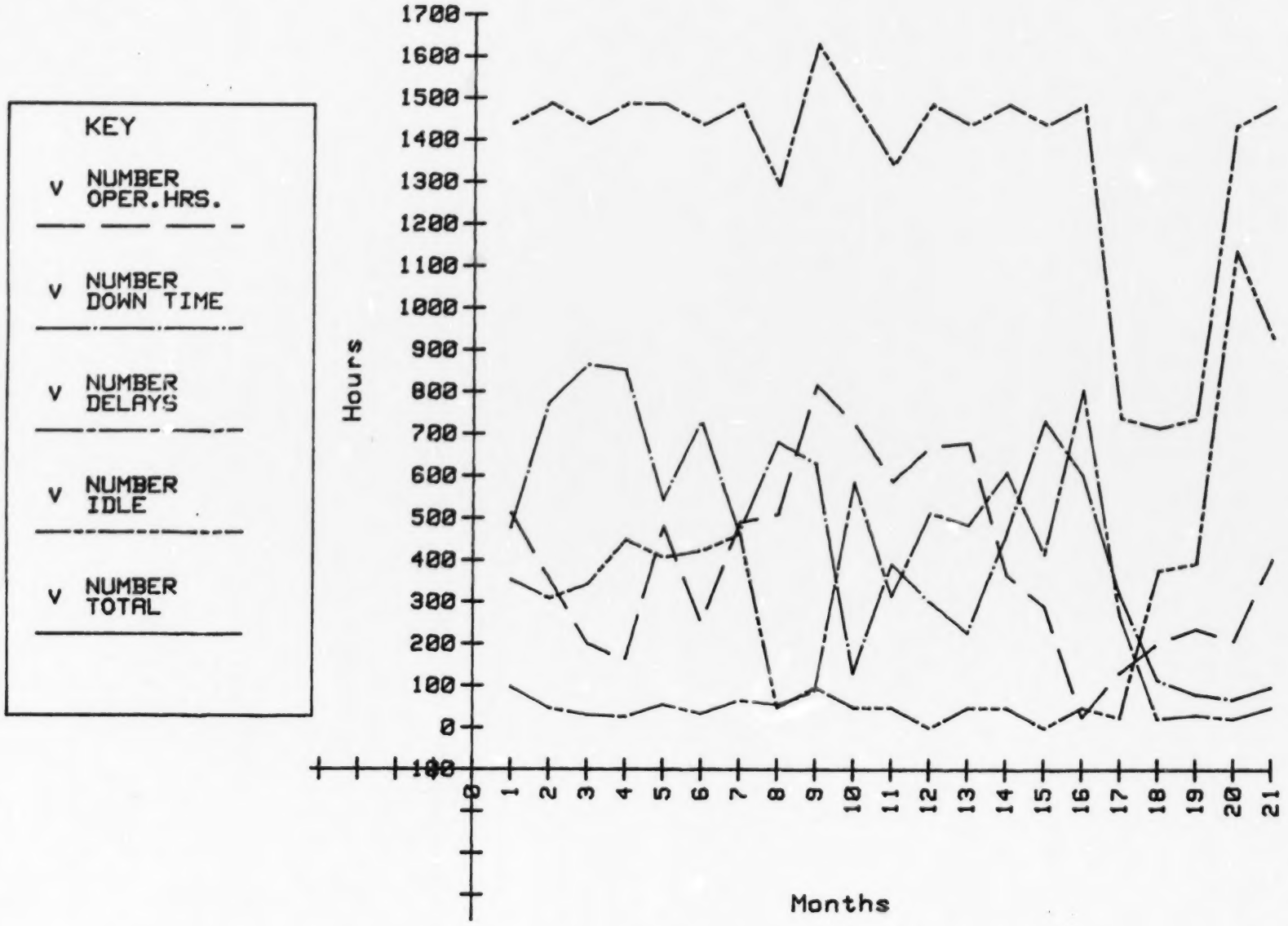

Fig. 6 - COAL HAULERS SUMMARY OF HOURS
CAT 772:91 Tonnes

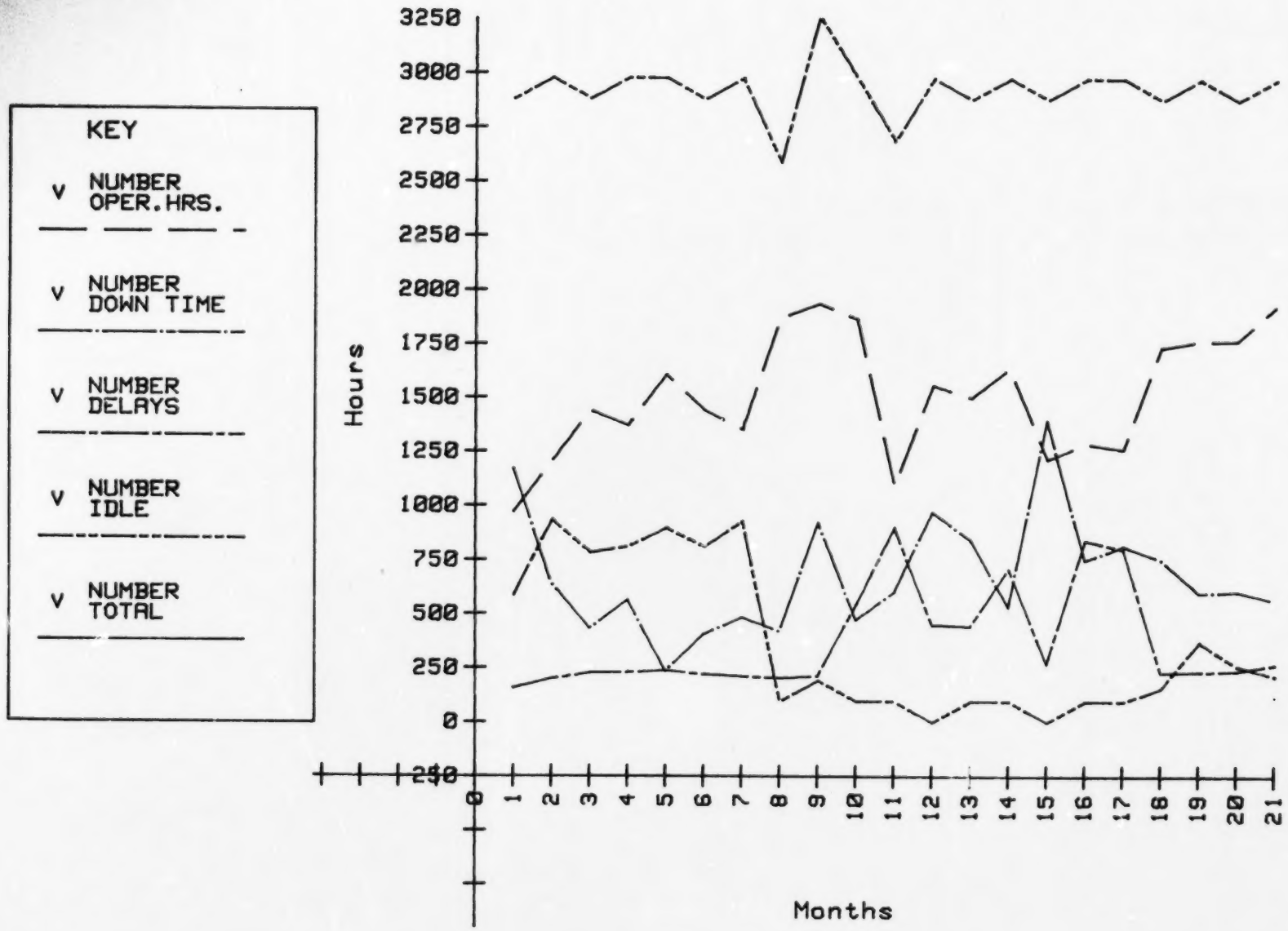

Fig. 7 - COAL HAULERS SUMMARY OF HOURS
TEREX 34-11C:136 Tonnes

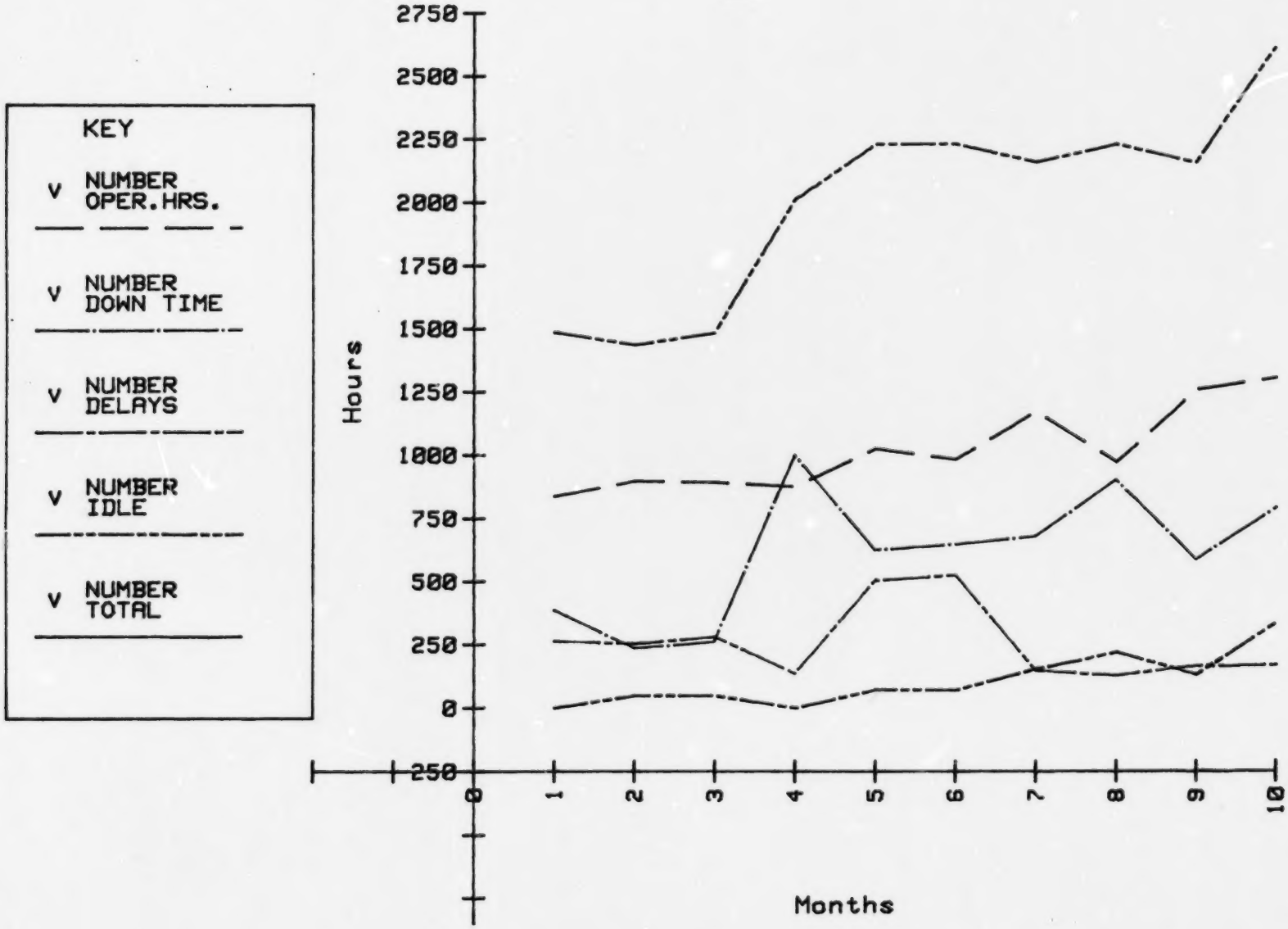

Fig. 8 - COAL HAULERS SUMMARY OF HOURS
KRESS CH-160:145 Tonnes

At the Highvale Mine, the truck load factors are determined by using the 100 ton trucks as a base and all other trucks are related to this base (1):

100 ton .....100/100 = 1.00
150 ton .....150/100 = 1.50
160 ton .....160/100 = 1.60

For example, Kress trucks have 60% higher load capacity than Euclid or Caterpillars trucks, etc.

100 ton .....104.0 m^3 .....104.0/104 = 1.00
150 ton .....165.9 m^3 .....165.9/104 = 1.60
160 ton .....176.0 m^3 .....176.0/104 = 1.69

Using Highvale Mine historical data (since September 1980) the load factors are:

Euclid 81.8T
Cat 81.8T
Terex 130.9T
Kress 138.3T

This calculation was averaged for the period of August 1982 to November 1983 and the following number of loads:

100 ton 36 097
150 ton 26 908
160 ton 14 019
Total tonnage 8 414 880

A loose coal density of 0.920 t/m^3 was used and applied to the SAE 2:1 capacities. The theoretical tonnage capacities therefore are:

Euclid ..... 95.7 T
Cat ..... 95.7 T
Terex .....152.6 T
Kress .....161.9 T

And finally, using these values, the truck fill factors are calculated as follows:

Euclid.....81.8/95.7 = 85.5%
Cat .....81.8/95.7 = 85.5%
Terex .....130.9/152.6 = 85.8%
Kress .....138.3/161.9 = 85.4%

The ash trucks capacities are:

a. Fly ash
   55.7 dry tonnes
   65.5 wet tonnes

b. Bottom ash
   43.4 dry tonnes
   66.7 wet tonnes

The fly ash hauled to Pit 02N represents approximatly 60% of the total ash hauled.

By comparing these fill factors of ash trucks and coal haulers with truck indicators, the comparability index was calculated (Table 14).

Table 14 - Comparability index

Truck	Load factor (1)	Oper.eff. (2)	Mech.avail. (3)	Operating eff. index (4)	Mechanical avail.index (5)
Ash:					
Euclid R85:77T					
Fly ash dry	55.7	0.8173	0.7425	45.5	41.4
Fly ash wet	65.5			53.5	48.6
Bottom ash dry	43.4			35.5	32.2
Bottom ash wet	66.7			54.5	49.5
Coal:					
Euclid R85:91T	81.8	0.7777	0.6338	63.6	51.8
Cat 772:91T	81.8	0.6429	0.4653	52.6	38.1
Terex 34-11C	130.9	0.8029	0.6918	105.1	90.6
Kress CH-160	138.3	0.7983	0.6258	110.4	86.5
Average (coal)	-	0.7762	0.6295	82.9	66.8

The operating efficiency index (4) and mechanical availability index (5) will give the true values for comparison of trucks used at Highvale Mine and it will determine the true productivity. Mine operator at Highvale Mine is assuming productivities at 95% of operating efficiency.

By comparing the coal haulers operating efficiency index and mechanicai availability index, it was concluded that Kress trucks will give the best operating efficiency and Terex trucks have the best mechanical availability. This conclusion is based on results for the period when only a limited number of Kress trucks operated at Highvale Mine the Kress trucks were recently introduced to mining operation. Therefore, it is expected that the index will change in the future.

The above is not an absolute comparison of off-highway vehicles. The introduced index should be compared with cost per unit of material hauled to obtain true cost evaluation. However, for the purpose of this study index values will satisfy the requirements.

3.8 REPORTING AND ASSIGNMENT

The following reports are presently produced at Highvale:

1. Daily Highvale Mine report (Table 15)
   List of equipment in pit and cut locations.
2. Coal handling and hauling operation (Table 16)
   List of equipment, hours operating, down delays, idle and total, diesel fuel consumed and reason for tire repair.
3. Coal/ash hauler summary of hours for year (Table 17)
   Summary of hours operating, down, delays, idle and total for month ending and to-date.
4. Coal deliveries (Table 18, 19, 20)
   Delivery of coal to R.O.M. hoppers, Keephills plant and MCL stockpile. Separate report for each location. Report include number of loads from different trucks and seams, specifying loader and their location. Weightometer reading at production and plantburn, coal distribution by pit and seam is also included.
5. Parting moved (Table 21)
   List of partings at various pits, by the seam, pit and total.
6. Shift production summary (Table 22)
   Production summary for day (D) and night (S) shift, trucks by the number of loads and average tonnage, summary of total loads and total tonnages.
7. Monthly production summary (Table 23)
   Production summary for each month by types of trucks and for each location (R.O.M., Keephills, MCL stockpile).
8. Contractors productivity load factors (Table 24)
   Number of loads on monthly basis for each type of trucks and total tonnage. Report is for each location.

Presently, the daily trucks dispatch and assignment are done manually on an "as needed" basis. Before the shift each truck is assigned its working location, loading unit, and dump location. In addition, the seam and pit are specified with access and exit ramp number. Time for daily preventive maintenance (top up) and number of "down" trucks is also shown.

Table 15 - Daily Highvale Mine Report

Daily Highvale Mine Report for _____19__ Reported by _____ to _____			
Equipment	Location		Comments
	Pit	Cut	
Dragline 8050			
7800			
1360			
Shovels 1247 No.1			
(190B) 1320 No.2			
1337 No.3			
1353 No.4			
P&H Shovel 11cy.m 8360			
Coal Haulers 1271			
91 Tonne Euclid 1272			
1329			
1330			
1331			
91 Tonne Cat. 7815			
7836			
136 Tonne Terex 8029			
8030			
8031			
8032			
145 Tonne Kress 8304			
8312			
8363			
Water Truck 1127			
1128			
Dart Loader 8056			
16G Grader 8217			
16G Grader 8142			
16G Grader 0218			
End Dump Truck 8126			
End Dump Truck 8127			
End Dump Truck 8225			
Hitachi Backhoe 8203			
Crane 8074			
D8 Cat 8017			
D9 Cat 7990			
355 Komatsu 8349			
455 Komatsu 8358			
D9L Cat 8216			
0227			
8357			
Scraper 637D 8026			
637D 8067			
637D 8068			
Coal Handling 1 & 2			
Coal Handling 3 & 4			
Coal Handling 5 & 6			
Keephills - C.H.P.			
Reclamation 627 8289			
627 8296			
631D 0226			
631D 8351			
D9H 7819			
D8K 7820			
D9L 8210			
Ash Hauler 77t 1267			
77t 1268			
77t 1269			
77t 1270			
Visitors			
Miscellaneous			

Table 16 - Coal handling and hauling operation

Equipment	Operating	Down	Delays	Idle	Total hours	Diesel fuel consumed	Reason for repair tire
Water truck 1127							
Water truck 1128							
77 Tonne 1267							
77 Tonne 1268							
77 Tonne 1269							
77 Tonne 1270							
91 Tonne 1271							
91 Tonne 1272							
91 Tonne 1329							
91 Tonne 1330							
91 Tonne 1331							
91 Tonne 7815							
91 Tonne 7836							
136 Tonne 8029							
136 Tonne 8030							
136 Tonne 8031							
136 Tonne 8032							
145 Tonne 8304							
145 Tonne 8312							
Coal H.P.(A) 1130							
Coal H.P.(B) 1305							
Coal H.P.(C) 7806							
Coal H.P.(D) 0206							

Table 17 - Coal,ash haulers summary of hours

Hauler	A Operating hours		B Down hours		C Delay hours		D Idle hours		E Total hours	
	Month	To date	Month	To date	Month	To date	Month	To date	Month	To date
Euclid R85 Ash Hauler										
Unit 1267										
Unit 1268										
Unit 1269										
Unit 1270										
TOTAL										
COAL HAULERS:										
91 Tonnes Euclid R85										
Unit 1271										
Unit 1272										
Unit 1329										
Unit 1330										
Unit 1331										
TOTAL										
91 Tonne Cat 772										
Unit 7815										
Unit 7836										
TOTAL										
136 Tonnes Terex 34-11C										
Unit 8029										
Unit 8030										
Unit 8031										
Unit 8032										
TOTAL										
145 Tonnes Kress										
Unit 8032										
Unit 8312										
TOTAL										
GRAND TOTAL										

Table 18 - Highvale mine-Sundance plant coal deliveries to ROM hoppers

Date: Shift:

Unit No	Seam #1	Seam #2	Seam #3	Seam #4	Seam #6	TAU Stockpile	MCL Stockpile	Totals	Loader	Location
1272										
1272										
1272										
1329										
1330										
1330										
Subtotal										
0029										
0031										
0032										
0032										
Subtotal										
TOTAL										

Weightometer readings - production

Hoppers	ROM 162 present previous tonnes	ROM scale	Hoppers	ROM 364 present previous tonnes	ROM scale	Hoppers	ROM 566 present previous ton	ROM scale	
									Production=

Weightometer readings - plantburn

North	Unit 162 present previous tonnes	South	North	Unit 364 present previous tonnes	South	East	Unit 566 present previous tonnes	West	
									Plantburn=

Coal distribution

Pit 02S #1 seam =
Pit 03 #4 seam =
Pit 03 #1 seam =
Pit 03 #2 seam =

Comments

Tonnes per load - 100 ton trucks =
Tonnes per load - 150 ton trucks =
Cycle time =

Table 19 - Highvale mine-Keephills plant coal deliveries to ROM hoppers

Date: Shift:

Unit No	Seam #1	Seam #2	Seam #3	Seam #4	Seam #6	TAU Stockpile	MCL Stockpile	Totals	Loader	Location
7815									1320	NWM
Subtotal										100 ton loads
8032									1320	NWS
Subtotal										150 ton loads
TOTALS										for all trucks

Weightometer readings - production

Hoppers	ROM 162 present previous tonnes	ROM scale
200		
100		
100		

Production =

Weightometer readings - plantburn

East	Unit 566 present previous tonnes	West

Plantburn =

Total Unit 1 =

Coal distribution

Pit 02S #1 seam =

Comments

Tonnes per load - 100 ton trucks =
Tonnes per load - 150 ton trucks =
Cycle time =
Scale zeroed when calibrated therefore adding ...tonnes to actual reading - May 11/83

Table 20 - Highvale mine-Manalta stockpile coal deliveries to ROM hoppers

Date: Shift:

Unit No	Seam #1	Seam #2	Seam #3	Seam #4	Seam #6	TAU Stockpile	MCL Stockpile	Totals	Loader	Location
1271									1337	SW35
1330									1337	SW35
Subtotal									100 ton loads	
8031									1353	NW4
Subtotal									100 ton loads	
8304									1353	NW4
Subtotal									160 ton loads	
TOTALS									for all trucks	

Coal distribution

Pit 02S #2 seam - NW4
Pit 03 #4 seam - SW35

Comments

Tonnes per load ... 100 ton trucks =
Tonnes per load ... 150 ton trucks =
Tonnes per load ... 160 ton trucks =
Cycle time =

Production =

Table 21 - Parting moved

No.	Parting moved			
	Date:			
Seam	Pit 02S	Pit 02N	Pit 03	Total
#2SM	13 733	0	42 191	55 924
#3SM	14 029	0	62 895	76 924
#4SM	34 496	0	59 334	93 830
#6SM	85 342	0	126 394	211 736
Total	147 600	0	290 814	438 414

Table 22 - Shift production summary

Shift Produciton Report								
Date	100T		150T		Ktons		Total	
	Loads	Average	Loads	Average	Loads	Average	Loads	Average
1-D								
2-S								
2-D								
3-S								
3-D								
4-S								
4-D								
.								
.								
.								
Total								

Table 23 - Monthly production summary

Monthly Production Summary					
Month	Total loads	70 ton loads	100 ton loads	150 ton loads	Total
Jan/81 Feb/81 Mar/81 . . . Jan/82 Feb/82 Mar/82 . . .					
Total					

Table 24 - Contractor productivity/load factors

Contractor Productivity/Load Factors				
Month	100T loads	150T loads	160T loads	Tonnages
Jan/82 Feb/82 . . Jan/83 Feb/83				
Total				
Load factors				
Note				

As a general rule, the size of a truck governs its use. The smallest haulers are assigned on shortest hauls first, then the mid-sized haulers on the shortest remaining haul, etc.

Table 25 - Daily assignment schedule

Date: May 30, 1984 Night Shift								
Truck	Top up	Loading unit	Station	Pit	Ramp		Tiple	
					In	Out	HV	KH
7815	down							
7836	yard							
1271	down	1247	2	03	32	31	5-6	
1272	10:00							
1329	yard							
1330	10:30	1247	2	03	32	31	5-6	
1331	down							
8029	11:00	1320	1	02	06	05	5-6	
8030	down							
8031	11:30	1320	1	02	06	05	5-6	
8032	12:00	1320	1	02	06	05	5-6	
8034	12:30	1247	2	03	32	31	ROM	
8312	01:00	1247	2	03	32	31	ROM	
.								
.								
.								
8126	-	1397	6	03			west	
8127	-	1337	6	03			mined	
8225	-	1353	4	02			out area	

Table 25 shows the proposed work schedule for the shift. A total of 7 trucks were assigned to haul the coal, of which 4 trucks were down for various reason, and 2 trucks were ready in yard (after maintenance completed, or driver is not available, or there is no work available for the truck). The production is from two pits only, Pit No 03 and 02 with two shovels working - No. 1247 in Pit 03 on Seam No. 2, No. 1320 in Pit 02 on Seam No. 1. The access to Pit 03 is by ramp 32 and exit by ramp 31, while the access to Pit 02 is by ramp 6 and exit by ramp 5. Dumping is at tiple 5-6 (south hoppers) for all trucks, except for two Kress trucks (8304, 8312) which dump at Highvale 3-4 hoppers. Two small Wabco trucks (8126, 8127) are used

to remove partings above Seam No. 6 in Pit 03, where loading is by shovel No. 1337. One Wabco truck (8225) is assigned to remove partings above seam No. 4 in Pit 02. The loading is by shovel No. 1353.

The computer model proposed for Highvale Mine should be able to handle trucks assignments more efficiently. Table 25 for "Daily assignment schedule" could be used, but should be updated. The driver should be informed for how long he is assigned to work at one location before he should move somewhere else. The computer model should also evaluate the situation better in the pit to improve handling of truck assignment.

4. SHOVELS

4.1 PRODUCTIVE OPERATION

The shovel production depends on the type of material loaded, angle of swing, and height of bank, height of dumping and the overall job efficiency. An additional factors include the ability of the shovel operator, bucket factor (swell of material), slope of ground on which a machine works, and external factors such as weather and the supply of hauling units. To allow for such variables, shovel manufacturers have recommended correction factors to specify machine efficiency and cycle times (4). The following production tables have been compiled using this information

Table 26 - Job efficiency factor

Job conditions	Management condition			
	Excellent	Good	Fair	Poor
Excellent	.84	.81	.76	.76
Good	.78	.75	.71	.65
Fair	.72	.69	.65	.60
Poor	.63	.61	.57	.52

The job condition includes all external factor associated with the site conditions, and management condition includes operator efficiency, work organization, etc. The job condition is, to some extent, unchangeable, whereas management condition could always be improved.

Table 27 - Depth of cut/swing angle correction factor

Depth of cut in % of optimun	Angle of swing (degrees)						
	45	60	75	90	120	150	180
40	.93	.89	.85	.80	.72	.65	.59
60	1.10	1.03	.96	.91	.81	.73	.66
80	1.22	1.12	1.04	.98	.86	.77	.69
100	1.26	1.16	1.07	1.00	.88	.79	.71
120	1.20	1.11	1.03	.97	.86	.77	.70
140	1.12	1.04	.97	.91	.81	.73	.66
160	1.03	.96	.90	.85	.75	.67	.62

NOTE: Depth of cut is vertical distance shovel bucket must travel to obtain load. Optimum distance varies with type of material excavated. A rule of thumb used is: optimum depth at cut is equal to vertical distance from dipper stick pivot shaft to ground level.

Table 28 - Bucket fill factors

Material	Fill factor range	
	Min	Max
Sand & gravel	.90	1.00
Earth, coal	.80	.90
Hard clay	.65	.75
Wet clay	.50	.60
Rock, well blasted	.60	.75
Rock, poorly blasted	.40	.50

Using the values from Tables 26 to 28, the production is therefore determined as follows:

Production (m^3) = max. production * job eff. factor * swing & depth factor * bucket load factor.

The maximum production is established using (bank m^3) measure for 60 minutes, 100% efficiency, 90° swing, grade level loading of all material into hauling units, and an optimum digging depth.

4.2 NON-PRODUCTIVE TIMES

There are several types of non-productive shovel times, namely:

1. Bench cleaning
2. Shovel moving
3. Mechanical delays
4. Waiting for trucks
5. Weather
6. Coffee/lunch breaks
7. Shift change
8. Other delays

Items 1 and 2 are usually performed by the shovel when no truck is waiting to be loaded. The shovel operator will move to a better or advanced position during the time of waiting for trucks. In unforeseen circumstances (slipping of coal wall, dropping of large quantity of coal from dipper, spoiling of coal from truck, etc.) the shovel will stop loading and clean the bench. It was also observed at several occasions, that front-end loaders cleared the bench for the shovel. It is accepted that loss of time because bench cleaning and shovel moving at the Highvale Mine is minimum and does not affect the mine production significantly.

When the shovel moves to another bench, trucks are diverted to thenext shovel that is ready and waiting to resume production.

The mechanical delays are, of course, unforeseen delays. During the shovel breakdown, trucks are diverted to another shovel. Excessive queuing times were observed during events like this.

The non-productive time of shovels (waiting for trucks) is the major time loss at the Highvale Mine. In average, up to three trucks are assigned to one shovel. It is estimated that with proper planning of truck times, shovel could handle double that number of trucks. The shovel operator usually uses the waiting time to prepare the bench for a move to better position or to do some clean-up around loading area. This time is also sufficient for the front-end loader to clean-up around shovel or to pile-up coal for shovel.

Bad weather can stop shovel production completely. This is not because shovels are not able to work during severe rain storms, but because coal haulers stop. It was observed on two occasions that coal haulers were not able to drive fully loaded over the pit floor and that they also start

sliding at the ramp exit. The shovel resumed production almost immediately after rain storm, but for the next hour the trucks were loaded at half its capacity only.

A total of 50 minutes in 12 hour shift is allocated for coffee/lunch breaks during which production stops. It was observed, that coffee times are very closely observed to ten minutes, as scheduled.

The shift change is included in the non-productive time of approximately 25-30 minutes duration. The shovel operators are picked up by the bus twenty minutes before the end of the shift, operation resume up to ten minutes after beginning of the next shift. Other non-productive delays observed are stoppage to receive instruction from the pit foreman, no-power situations, waiting for the water truck to pass by, etc. These delays are negligible and could be ignored in describing pit operation for modelling purposes.

4.3 REPORTING AND ASSIGNMENT

The shovel operator is assigned to its shovel at the beginning of the shift. He can read from the truck assignment chart how many trucks are allocated to him and on which seam in pit he is to work on. Shovel operators are assigned to the same shovel each time as a rule. It was observed on two occasions only that shovel operator was transferred to another shovel during the same shift.

The following reports are recommended to be produced by the computer model to monitor shovel operation:

1. Production report (Table 29): number of trucks loaded, number of loads, non-productive times.
2. Daily log report (Table 30): report on loading, non-productive times, delays, etc.
3. Operator report (Table 31): memos by one operator to other operator, suggesting work methods or for identifying problems. This report should be filled in at the dispatch office.

Table 29 - Production report

Shovel no.	Time of shift													Summary	
	7	8	9	10	11	12	13	14	15	16	17	18	19	Total	Average
Truck no.														(min)	(min)
Actual truck no. used 1 2 3 4 5															
No. of loads (by dipper)														No. of loads	Average
loads by truck no. 1 2 3 4 5															
Note														(min)	(min)
Non-productive time (min)															

Table 30 - Daily log report

Shovel No.:	Operator				Day:			Shift:		
Time	Event									
	Loading	Bench cleaning	Shovel moving	Mech. delay	Waiting	Weather delay	Coffee delay	Shift change	Other delays	Note
0700 0710 0720 0730 0740 . . . 1750 1900										
Total										
Ave.										

Table 31 - Operator report

Shovel no.:	Operator:	Day:	Shift:
Memo:			

Other reports for trucks and shovels could be made available to permit studies of downtime, weather, fueling, wrong assignment effects, dispatching. The actual results could be compared with simulation results, including operating cost per hour and per ton, for each type of the equipment and each job function.

The following output reports may also be provided (7):

1. Production statistics
2. Queuing
3. Material properties
4. Blending
5. Equipment used
   - cycle times
   - volumes or tonnages moved (BCM,T)
   - energy consumed (KWH,L)
   - cost per tonne (or m^3)
   - delay times/working times
   - production rates (BCMPH, TPH)
6. Alphanumeric display of ongoing simulation results updated at intervals (split screen for user to enter commands via the same device).
7. Graphic display with selectable levels of detail and content. The user could select overview of entire mine, or pit, or details of pit.
8. Accounting/cost studies
9. Haulage, pit, dump, equipment utilization
10. Immediate reporting or interval reporting
11. Equipment reassignment
12. Truck haulage information
    - truck no.
    - material hauled
    - load site/dump site
    - no. of loads
    - average truck cycle times
    - total working, idle, down times
    - fuel consumption (LPH)
    - specific energy consumption (KWH/BCM)

- time heating index (TMPH)
- operating efficiency (%)
- total production (BCM)

13. Fleet information
    - fleet utilization

$$F.U. = \frac{\text{total working time}}{\text{elapsed time x no. of trucks}} \times 100\%$$

    - fleet efficiency

$$F.E. = \frac{\text{ave. cycle time (no delays)}}{\text{ave. cycle time (with delays)}} \times 100\%$$

14. Truck utilization
    - truck no.
    - accumulated times and pencentage of elapsed time spent for:
      . hauling
      . waiting
      . relocating
      . refueling
      . tire service
      . clean up
      . shift change
      . break periods
15. Equipment model (shovel, etc.)
    - cycle times
    - volumes/tonnages
    - energy consumption (KWH, Litres)
    - mining cost per tonne or cubic metre
    - spoil geometry
    - machine characteristics
    - operating and maintenance time to achieve required production
    - stripping ratio BCM/tonne
    - stripping rate BCMPH, production rate TPH
    - dragline swing angles, similar results for BWE, shovels
    - production hours for all units, overall productivity

- overburden and coal production per pit per specific time period, total mine production
- breakdown of stripping quantities in terms of normal rehandle, extended bench, prestripping
- quantities of partings by cut, by pit and for entire mine
- status of pit and the stockpile reserves
- percentage of rehandle associated with particular pit sections or time periods.

Additional reports could be developed as required by the mine management. For example, it could be power consumption report, inspection report, maintenance and repair log book, etc.

5. CONCLUSION

The Highvale Mine in Alberta is a multi-pit, multi-dump operation, consisting of three operating pits: 02-8, 03 and 04, and three dumping areas: Sundance, Keephills, Manalta's coal storage. The trucks and shovels are the main equipment of coaling operation and therefore any improvement in productivity is directly dependent on the efficiency of the truck/shovel system.

In this report, the coal hauling operation is described, together with the reporting and assignments of the trucks. The mining practices known from other operations and factors used elsewhere are listed here and evaluated for possible use in development of computer based model of Highvale Mine truck/shovel system. These factors are practices recommended are:

1. Trucks Only
   - Rolling ressistance values in the range of 2.0 to 20.0% of grade equivalent.
   - The coefficient of traction for different material in range of 0.1 to 0.9.
   - The life factor 0.38 for coal haulers and 0.43 for ash haulers.
   - Load factor for selected material in range from 0.59 to 0.93.
   - Dipper factor for shovels for loading of rock at 0.40 to the loading of loose material at 0.90.

The availability and utilization values, using the Highvale Mine historical data, were evaluated and summarized. Using these values, the operating and non-productive indicators for ash and coal haulers were summarised and the operating efficiency and the mechanical availability index for each type of truck was introduced.

2. Shovels Only

- The shovels job efficiency factor was introduced. This combines management condition with on site job condition. It ranges from 0.52 for poor to 0.84 for excellent, depending on these two factors.
- The depth of cut/swing angle correction factor was established for the range of 40 to 160 m deep and for swing angle of 45° to 180°.
- Bucket fill factors was introduced for different materials at Highvale Mine ranging from 0.40 to 1.00.

The evaluation of non-productive times was completed based on several factors that are predictable and therefore could be minimized, to factors that are unpredictable.

Various forms presently used for event reporting at Highvale Mine, for both truck and shovel are listed and recommended to be used by the computer based reporting. Several other reporting factors are recommended that could also better utilize outputs from the computer model.

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